FORM PTO-1390 (Rev 5-93) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER: **ZAHFRI P356US**

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

U.S. APPLICATION NO.: 09/890986

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/EP00/00894	**February 4, 2000**	**February 10, 1999**

TITLE OF INVENTION

ELECTRIC MACHINE

APPLICANT(S) FOR DO/EO/US

Max BACHMANN

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ■ This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.

2. □ This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.

3. ■ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).

4. ■ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

5. ■ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. □ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ■ has been transmitted by the International Bureau. (PCT/IB/308 mailed **17 August 2000**).
   c. □ is not required, as the application was filed in the United States Receiving Office (RO/US)

6. ■ A translation of the International Application into English (35 U.S.C. 371(c)(2)) is attached.

7. ■ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. □ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. □ have been transmitted by the International Bureau.
   c. □ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ■ have not been made and will not be made.

8. □ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. ■ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).

10. □ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ■ An Information Disclosure Statement under 37 CFR 1.97 and 1.98 with PTO FORM 1449.

12. ■ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

13. ■ A FIRST preliminary amendment.
    □ A SECOND or SUBSEQUENT preliminary amendment.

14. □ A substitute specification.

15. □ A change of power of attorney and/or address letter.

16. ■ Other items or information:
    - ■ Preliminary Examination Report
    - ■ Annexes to Pre. Ex. Rep.
    - ■ International Search Report
    - ■ German Novelty Search Report
    - ■ 22 copies of citations
    - ■ Form PCT/IB/308
    - ■ Int'l Publ. No. **WO 00/48291** (Face page only)
    - ■ Copy of Request
    - ■ Submission of Formal Drawings
    - ■ 8 sheets of formal drawings
    - ■ Abstract
    - ■ German Language Specification
    - ■ Marked-Up Version of Specification
    - ■ Submission of Proposed Dwg Amendments & 4 Dwgs (1,4,10 & 12)

CERTIFICATION UNDER 37 CFR 1.10

I hereby certify that this Transmittal Letter and the papers indicated as being transmitted therewith is being deposited with the United States Postal Service on this date **August 8, 2001** in an envelope as "Express Mail Post Office to Addressee" Mailing Label **Number EL918841155US** addressed to the: Commissioner of Patents and Trademarks, Washington, D.C. 20231.

Michael J. Bujold
(typed or printed name of person mailing paper)

(signature of person mailing paper)

17. ■ The following fees are submitted:	CALCULATIONS	PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)): Search Report has been prepared by the EPO or JPO $860.00	09/890986	
International preliminary examination fee paid to USPTO (37 CFR 1.482) $690.00		
No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)). $710.00		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $1000.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) $100.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	860	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	0	

Claims	Number Filed	Number Extra	Rate		
Total Claims	20 - 20 =	0	x $18.00	0	
Independent Claims	1 - 3 =	0	x $80.00	0	
Multiple dependent claim(s) (if applicable)			+ $270.00	0	
			TOTAL OF ABOVE CALCULATIONS =	860	
Reduction by 1/2 for filing by small entity, if applicable. **Applicant claims Small Entity Status**. (Note 37 CFR 1.9, 1.27, 1.28).				0	
			SUBTOTAL =	860	
Processing fee of $130.00 for furnishing the English translation later the ☐ 20 ☐30 months from the earliest claimed priority date (37 CFR 1.492(f)).			+	0	
			TOTAL NATIONAL FEE =	0	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property			+	40	
			TOTAL FEES ENCLOSED =	900	
				Amount to be: refunded	$
				charged	$

a. ■ A check in the amount of $ **900.00** to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. 04-0213 in the amount of $____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ■ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 04-0213 . A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Michael J. Bujold -- Registration No. 32,018
Davis & Bujold, P.L.L.C.
Fourth Floor
500 North Commercial Street
Manchester, NH 03101-1151
Telephone (603) 624-9220
Telefax (603) 624-9229

08/08/01

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	:	Max BACHMANN
Serial no.	:	
For	:	ELECTRIC MACHINE
Docket	:	ZAHFRI P356US

BOX PCT
The Commissioner of Patents and Trademarks
Washington, D.C. 20231

FIRST PRELIMINARY AMENDMENT

Dear Sir:

By way of preliminary amendment, please amend the above identified application as set forth below.

In the Drawings:

Please amend Figs. 1, 4, 10 and 12 per the attached.

In the Specification:

Please cancel paragraphs 2, 3, 4, 10, 11, 22 and 36 of the specification, in their entirety, in favor of a clean form of paragraphs 2, 3, 4, 11, 22 and 36 of the specification, without any markings thereon, as follows. Also accompanying this response is a copy of the original paragraphs of the specification which show the addition(s) (by underlining, shading and bold) and the deletion(s) (by strikeout) to the canceled specification paragraphs. Please enter the replacement specification paragraphs into the record of this case.

In the Claims:

Please cancel original claims 1-24, as well as any Chapter II amended claims, in favor of new claims 25-44 as follows.

[002] FIELD OF THE INVENTION

[003] The invention concerns an electrical machine, in particular, serving as an electric motor for a drive for vehicles.

[004] BACKGROUND OF THE INVENTION

[011] SUMMARY OF THE INVENTION

[022] BRIEF DESCRIPTION OF THE DRAWINGS

[036] DETAILED DESCRIPTION OF THE INVENTION

25. (NEW) An electrical machine (2) with an externally situated stator and an inward disposed rotor which is rotationally supported on bearings and has a rotor shaft (4) which is rotationally fixed with a rotor laminate pack (18) and said rotor shaft (4) is hollow or, possesses between the rotor laminate pack (18) and itself a hollow interposed shaft (26), upon which the rotor laminate pack (18) is placed, wherein the rotor shaft (4) has a cross-sectional shape of three sickle shaped webs (46) which allow a large quantity of cooling medium to pass between the rotor shaft (4) and the interposed shaft (26), i.e. the rotor laminate pack (18), and allows formation of a large heat transfer surface with a simultaneous endurance to stress energy upon placing the rotor shaft (4) in the rotor laminate pack (18) or in the interposed shaft (26).

26. (NEW) The electrical machine (2) according to claim 25, wherein the rotor shaft (4) and the hollow, interposed shaft (26) contact one another only along a linear contact zone to form smaller heat transfer areas.

27. (NEW) The electrical machine (2) according to claim 25, wherein the webs are interrupted along their entire length so as not to lie upon the interposed shaft (26).

28. (NEW) The electrical machine (2) according to claim 25, wherein the rotor shaft (4) is made from one of a separate forged component and by a precision molding and is pressed into the hollow interposed shaft (26) to achieve a force fit.

29. (NEW) The electrical machine (2) according to claim 25, wherein the rotor shaft is made from a material of relatively low heat conductivity.

30. (NEW) The electrical machine (2) according to claim 29, wherein the material of relatively low heat conductivity is a highly alloyed steel.

31. (NEW) The electrical machine (2) according to claim 29, wherein the material of relatively low heat conductivity is titanium.

32. (NEW) The electrical machine (2) according to claim 25, wherein an element (34) is provided for a turbulence-free guided flow of the cooling medium.

33. (NEW) The electrical machine (2) according to claim 25, wherein the cooling medium is air.

34. (NEW) The electrical machine (2) according to claim 25, wherein for the construction of a rotor shaft (4), which can allow a large quantity of cooling medium to flow between the rotor shaft (4) and the interposed shaft (26) and yet be constructed, at the same time, with sufficient structural strength, and the cross-section of said rotor shaft (4) is in the shape of a star with four webs (28).

35. (NEW) The electrical machine (2) according to claim 25, wherein for the construction of a rotor shaft (4), which allows a large quantity of cooling medium to pass between the rotor shaft (4) and the interposed shaft (26) and for the provision of a relatively large heat transfer surface at the same acceptance of stress energy, the rotor shaft (4) is in the shape of three sickle shaped webs (46).

36. (NEW) The electrical machine (2) according to claim 25, wherein the webs (28, 46) are interrupted so as not to lie along their entire length against the interposed shaft (26).

37. (NEW) The electrical machine (2) according to claim 25, wherein the rotor shaft (4) is manufactured from one of a separate forged part and a precision cast part and is pressed into the hollow interposed shaft (26) to achieve a press fit.

38. (NEW) The electrical machine (2) according to claim 25, wherein the rotor shaft (4) is made from a material of relatively low heat conductivity.

39. (NEW) The electrical machine (2) according to claim 38, wherein the material of relatively low heat conductivity is a high alloy steel.

40. (NEW) The electrical machine (2) according to claim 38, wherein the material of relatively low heat conductivity is titanium.

41. (NEW) The electrical machine (2) according to claim 25, wherein elements (34) to facilitate non-turbulent flow of the cooling medium are provided.

42. (NEW) The electrical machine (2) according to claim 25, wherein a heat exchanger (36) is integrated into the electrical machine (2).

43. (NEW) The electrical machine (2) according to claim 42, wherein the heat exchanger (36) possesses cooling tubes (44, 48) which encompass the stator.

44. (NEW) The electrical machine (2) according to claim 43, wherein the cooling tubes (44, 48) are located in heat transferring connection with the cooling ribs (38).

REMARKS

Accompanying this response, please find marked-up paragraphs of the specification which overcome some informalities noted in the specification on file. The undersigned avers that the enclosed replacement paragraph(s) of the specification do not contain any new.

The subject matter of the Chapter II amended claims is revised to conform with the United States claim format and entered as new claims 25-48. Please consider these new claims when considering this application.

In the event that there are any fee deficiencies or additional fees are payable, please charge the same or credit any overpayment to our Deposit Account (Account No. 04-0213).

Respectfully submitted,

Michael J. Bujold, Reg. No. 32,018
Customer No. 020210
Davis & Bujold, P.L.L.C.
Fourth Floor
500 North Commercial Street
Manchester NH 03101-1151
Telephone 603-624-9220
Facsimile 603-624-9229
E-mail: patent@davisandbujold.com

VERSION WITH MARKINGS TO SHOW CHANGES MADE

[001] # ELECTRIC MACHINE

[002] ## FIELD OF THE INVENTION

[003] The invention concerns an electrical machine, in particular, serving as an electric motor for a drive for vehicles ~~in accord with the generic concept of Claim 1~~.

[004] ## BACKGROUND OF THE INVENTION

[005] Machines of this type are mostly asynchronous machines, which are constructed with a stator within which a rotor is provided. The rotor is designed to be of the squirrel cage type and is made preferably of electrically conductive aluminum, which is precision cast in a mold to the shape of the rotor. The aluminum, during the production, is poured into grooves formed by the laminate pack of the rotor. On the end of the rotor, the aluminum coils from the respective grooves are brought together into a ring thereby forming the said squirrel cage winding. The asynchronous motors are predominately run under heavy duty conditions and the heat generation by said motors calls for optimized cooling.

[006] Such a machine has been disclosed, for instance, by EP 0 484 548 B1. The electrical machines of this disclosed type possess an inward disposed rotor with a rotor shaft and a rotor laminate pack and an externally located stator. This electrical machine is connected with the cooling system of the vehicle.

[007] A particular problem with the cooling of such an electric machine is found in the bearing method to support the rotor shaft and in their sealing means. The heat transmitted from the rotor shaft to the bearings leads to bearing damage and, over time, to the failure of the machine. Because of high temperatures in the rotor shaft, large temperature differences consequently arise in the bearings between the inner bearing ring and the outer bearing ring. At the same time, circulation of a cooling medium in the electrical machine is made especially difficult by construction limitations presented by the machine.

[008] This leads to the fact that the generated temperatures, especially in the case of machines under heavy duty service, can not easily be conducted away from the internals.

[009] The present invention thus has the purpose of proposing an electrical machine, which makes a better transport of the cooling medium possible and protects the bearing of the machine from damage.

[010] This purpose is achieved in accord with the invention by the features of Claim 1. Embodiments of the concept of the invention are described and explained as objects of the subordinate claims.

[011] SUMMARY OF THE INVENTION

[012] For the purpose of cooling the machine, the heat generated by its operation must be transferred to a cooling medium. The medium must be easily transportable to the individual machine. Air is an advantageous cooling medium which itself, after such use, can be again cooled or exchanged for free air. Air is an excellent insulator, on its account, so that in an electrical machine, no special insulation means need be called upon in order to protect the various components of the machine against short circuit problems, which could arise from the characteristics of notice cooling medium. In order to conduct the cooling medium into the machine safely, possible flow restrictions must be avoided in every possible way.

[013] In accord with the invention, a cooling medium can be conducted through an area between a rotor laminate pack and a rotor shaft in an electrical machine which possesses an externally disposed stator, an inner, rotatably, bearing supported, hollow rotor, a laminated rotor pack, and a rotor shaft, connected to rotate with the laminate pack. For this purpose, the rotor shaft can be directly placed, in a rotational fixed manner, within the rotor laminate pack or, in an advantageous embodiment, a hollow interposed shaft may be inserted between the rotor laminate pack and the rotor shaft upon which shaft the rotor laminate pack is placed. Another embodiment shows the rotor shaft as a webbed shaft which possesses a plurality of webs on its circumference.

[014] In yet another advantageous embodiment, means are provided between the rotor shaft and the interposed shaft, i.e. the rotor laminate pack, to transport the

[020] In a further favorable embodiment, a heat exchanger is integrated into the electrical machine. The heat exchanger can have cooling tubes, which surround the stator and said cooling tubes can communicate, in a heat transfer manner, with provided cooling ribs. Cooling tubes can be provided directly within cooling ribs, which, with the cooling tubes which surround the stator, are inter-connectable. These cooling tubes embedded in the cooling ribs can, in one version, be installed at an angle to the cooling tubes which surround the stator. One embodiment shows the cooling ribs placed in a separate construction component, which can be mounted in the form of a cooling basin to the electrical machine.

[021] A preferred version employs air as the cooling medium.

[022] BRIEF DESCRIPTION OF THE DRAWINGS

[023] The invention will be explained and described in greater detail with the help of the drawings in which:

[024] Fig. 1 is an electrical machine with a star shaped, webbed shaft,

[025] Fig. 2 is a cross-section through a webbed shaft an rotor shaft as in Fig. 1,

[026] Fig. 3 is a cross-section through the heat exchanger, as in Fig. 1,

[027] Fig. 4 is an electrical machine with a shaft having sickle shaped internal webs,

[028] Fig. 5 is a cross-section through a webbed shaft and rotor laminate pack of Fig. 4,

[029] Fig. 6 is an electrical machine with a ventilating apparatus in the rotor shaft,

[030] Fig. 7 is a cross-section through the webbed shaft and the rotor shaft of Fig. 6,

[031] Fig. 8 is an electrical machine with a webbing arranged as an internal screw coil,

[032] Fig. 9 is a cross-section through a heat exchanger which possesses a cooling basin,

[033] Fig. 10 is a further cross-section through a heat exchanger with a cooling basin,

[034] Fig. 11 is a cross-section through the cooling basin in accord with Fig. 9, and

[035] Fig. 12 is a cross-section through the cooling basin in accord with Fig. 10.

[036] DETAILED DESCRIPTION OF THE INVENTION

[037] Fig. 1 shows an electric machine 2 with a rotor shaft 4, which rotates on two sets of bearings, namely 6 and 8, which are enclosed in a housing 10. The rotor shaft 4 possesses a toothed end 11, proximal to the bearing, by means of which the electrical machine 2 coacts with additional (not shown) elements of a line of drive mechanism. A rotor, a stator laminated pack 12, through which a stator winding 14 penetrates is placed in the housing 10. A rotor laminate pack 18, separated by a spacer opening 16, is situated radially within said stator laminate pack 12. The rotor laminate pack 18 is penetrated by metal pins 20, which preferably are made of aluminum. A cap 24 is fastened onto the rotor laminate pack 18 with screws 22. As an alternative, the metal pins 20 can be embedded in the rotor laminate pack 18 in a precision molding operation. The rotor laminate pack 18 is seated on a hollow interposed shaft 26, circular in cross section. The rotor shaft 4 is placed with said interposed shaft 26 by press a fit, so that it rotates as one with the interposed shaft 26. The rotor shaft can, however, be press fit directly into the rotor laminate pack. The rotor shaft 4 possesses four webs 28, which are arranged in the shape of a star (see Fig. 2). The webs 28, in the embodiment depicted here, provide open spaces 29, so that the webs 28 do not lie along their entire length against the inner wall of the hollow interposed shaft 26. In the empty spaces 30, a first cooling medium, preferably air, can be circulated through the interposed shaft 26 between the webs 28, that is, for cooling the connected rotor laminate pack 18 thereto. For this purpose, a ventilating fan 32, which brings about a flow of the cooling medium, is placed on an axial end of the rotor laminate pack 18. A steel ring sheet 34, which directs the cooling medium flowing through a heat exchanger 36 in the direction of the interposed shaft 26, without turbulence, is provided on the other axial end of the rotor laminate pack 18. The heat exchanger 36 possesses cooling ribs 38 (see Fig. 3) through which the

08/08/01

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	:	Max BACHMANN
Serial no.	:	
For	:	ELECTRIC MACHINE
Docket	:	ZAHFRI P356US

BOX PCT
The Commissioner of Patents and Trademarks
Washington, D.C. 20231

SUBMISSION OF FORMAL DRAWINGS

Further to the filing of this application, enclosed please find eight (8) sheets of formal drawings which are to be entered in this case.

In the event that there are any fee deficiencies or additional fees are payable, please charge the same or credit any overpayment to our Deposit Account (Account No. 04-0213).

Respectfully submitted,

Michael J. Bujold, Reg. No. 32,018
Customer No. 020210
Davis & Bujold, P.L.L.C.
Fourth Floor
500 North Commercial Street
Manchester NH 03101-1151
Telephone 603-624-9220
Facsimile 603-624-9229
E-mail: patent@davisandbujold.com

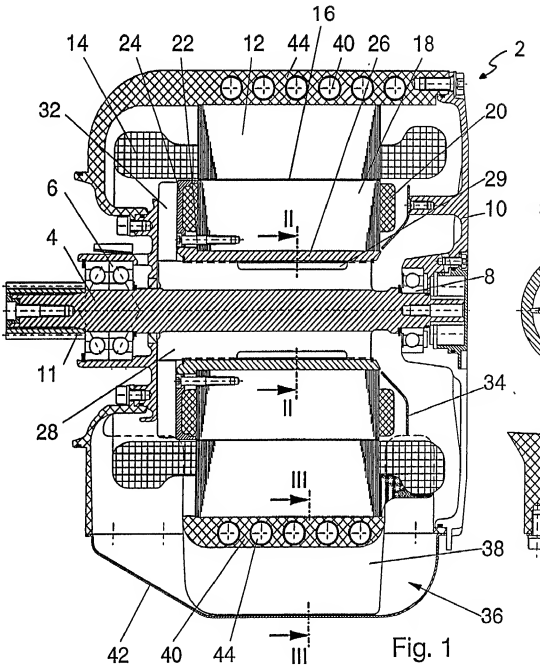

Fig. 1

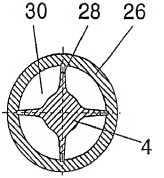

Fig. 2

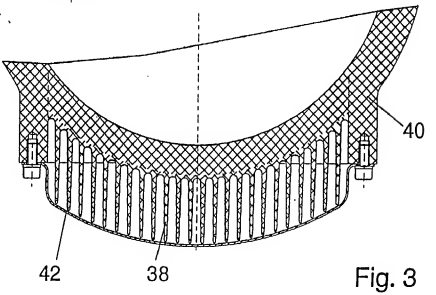

Fig. 3

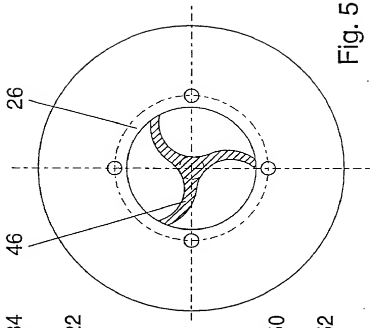

Fig. 5

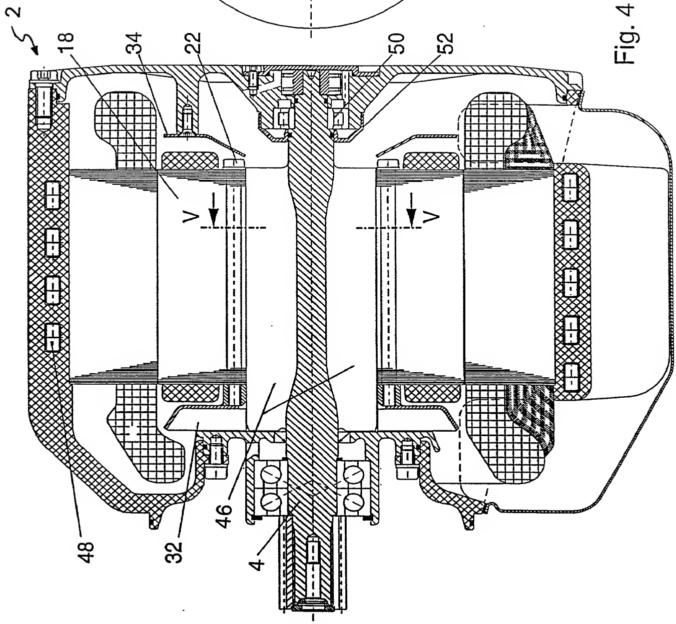

Fig. 4

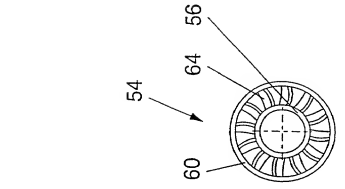

Fig. 7

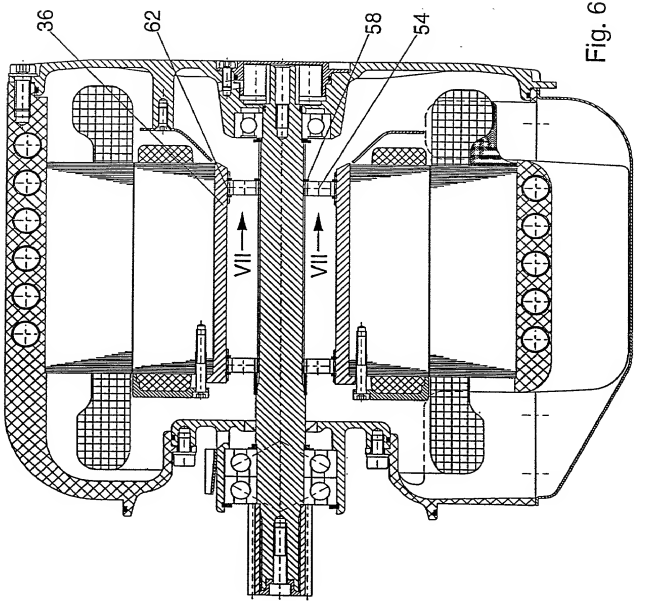

Fig. 6

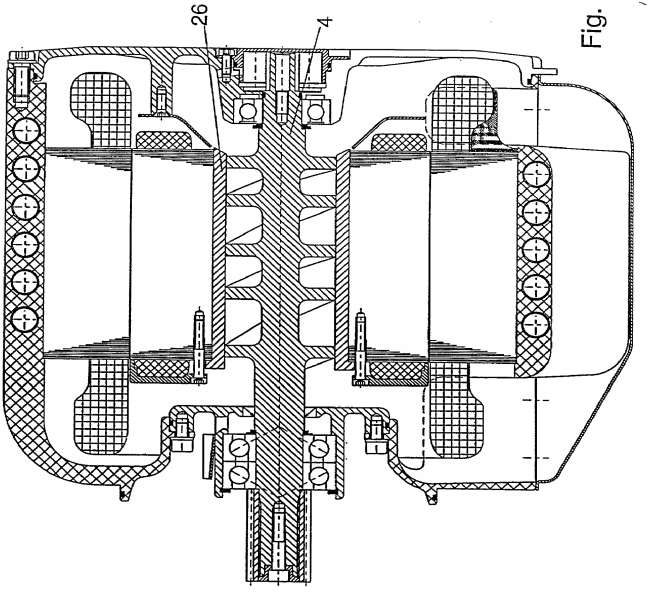

Fig. 8

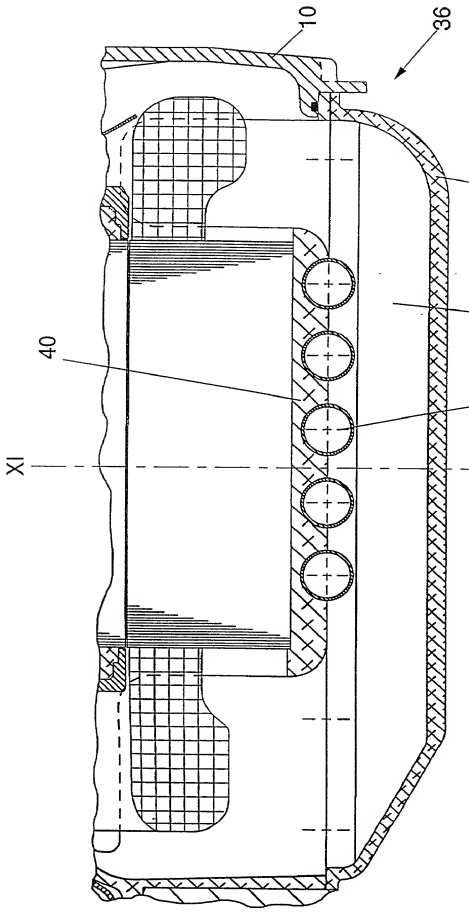

Fig. 9

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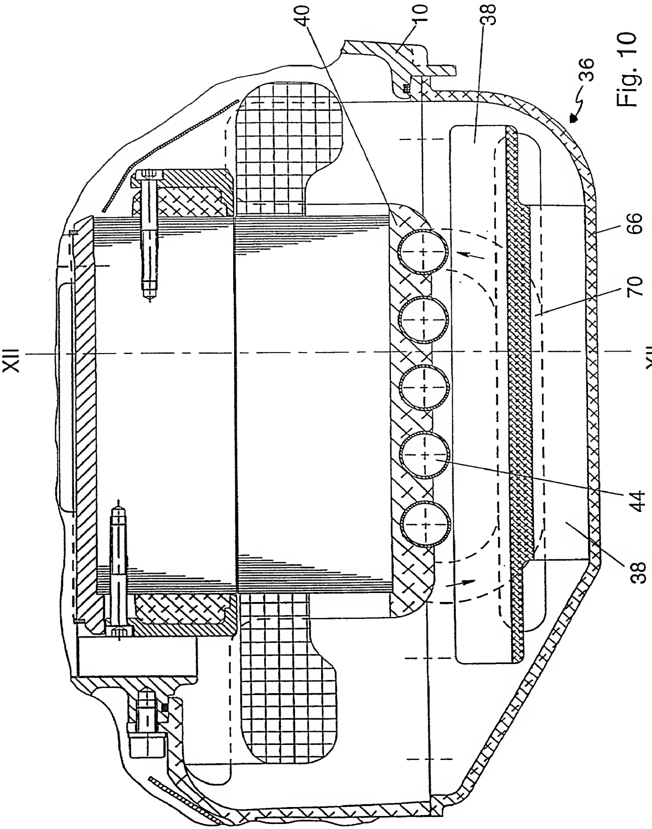

Fig. 10

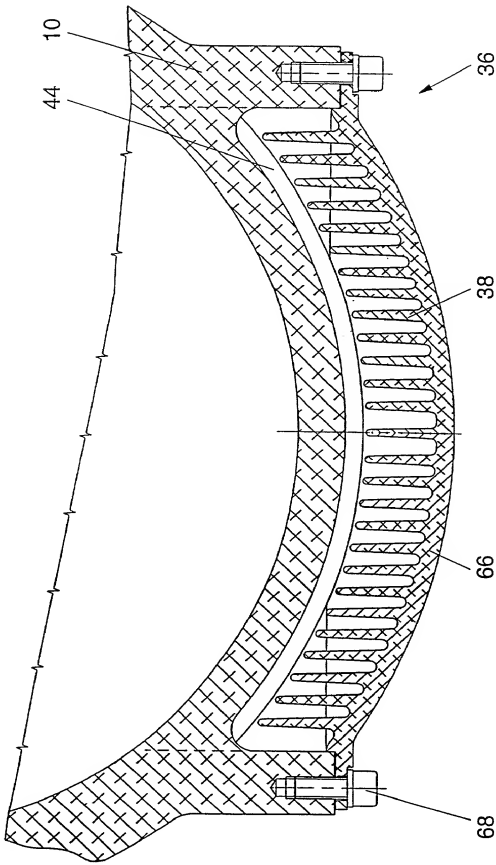

Fig. 11

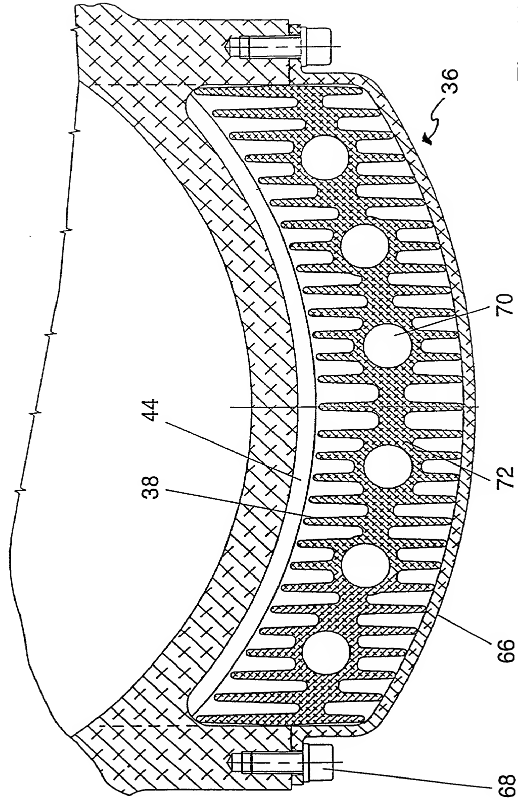

Fig. 12

[001] ELECTRIC MACHINE

[002]

[003] The invention concerns an electrical machine, in particular, serving as an electric motor for a drive for vehicles in accord with the generic concept of Claim 1.

[004]

[005] Machines of this type are mostly asynchronous machines, which are constructed with a stator within which a rotor is provided. The rotor is designed to be of the squirrel cage type and is made preferably of electrically conductive aluminum, which is precision cast in a mold to the shape of the rotor. The aluminum, during the production, is poured into grooves formed by the laminate pack of the rotor. On the end of the rotor, the aluminum coils from the respective grooves are brought together into a ring thereby forming the said squirrel cage winding. The asynchronous motors are predominately run under heavy duty conditions and the heat generation by said motors calls for optimized cooling.

[006] Such a machine has been disclosed, for instance, by EP 0 484 548 B1. The electrical machines of this disclosed type possess an inward disposed rotor with a rotor shaft and a rotor laminate pack and an externally located stator. This electrical machine is connected with the cooling system of the vehicle.

[007] A particular problem with the cooling of such an electric machine is found in the bearing method to support the rotor shaft and in their sealing means. The heat transmitted from the rotor shaft to the bearings leads to bearing damage and, over time, to the failure of the machine. Because of high temperatures in the rotor shaft, large temperature differences consequently arise in the bearings between the inner bearing ring and the outer bearing ring. At the same time, circulation of a cooling medium in the electrical machine is made especially difficult by construction limitations presented by the machine.

[008] This leads to the fact that the generated temperatures, especially in the case of machines under heavy duty service, can not easily be conducted away from the internals.

[009] The present invention thus has the purpose of proposing an electrical machine, which makes a better transport of the cooling medium possible and protects the bearing of the machine from damage.

[010] This purpose is achieved in accord with the invention by the features of Claim 1. Embodiments of the concept of the invention are described and explained as objects of the subordinate claims.

[011]

[012] For the purpose of cooling the machine, the heat generated by its operation must be transferred to a cooling medium. The medium must be easily transportable to the individual machine. Air is an advantageous cooling medium which itself, after such use, can be again cooled or exchanged for free air. Air is an excellent insulator, on its account, so that in an electrical machine, no special insulation means need be called upon in order to protect the various components of the machine against short circuit problems, which could arise from the characteristics of notice cooling medium. In order to conduct the cooling medium into the machine safely, possible flow restrictions must be avoided in every possible way.

[013] In accord with the invention, a cooling medium can be conducted through an area between a rotor laminate pack and a rotor shaft in an electrical machine which possesses an externally disposed stator, an inner, rotatably, bearing supported, hollow rotor, a laminated rotor pack, and a rotor shaft, connected to rotate with the laminate pack. For this purpose, the rotor shaft can be directly placed, in a rotational fixed manner, within the rotor laminate pack or, in an advantageous embodiment, a hollow interposed shaft may be inserted between the rotor laminate pack and the rotor shaft upon which shaft the rotor laminate pack is placed. Another embodiment shows the rotor shaft as a webbed shaft which possesses a plurality of webs on its circumference.

[014] In yet another advantageous embodiment, means are provided between the rotor shaft and the interposed shaft, i.e. the rotor laminate pack, to transport the

cooling medium. For this purpose, in one embodiment the rotor shaft possesses webs which are in the form of diffusor blades.

[015] One embodiment shows the rotor shaft designed in the shape of a screw conveyor. Another embodiment shows at least one ventilating apparatus located between the rotor shaft and the interposed shaft, i.e. the rotor laminate pack.

[016] Yet another embodiment shows the rotor shaft with ventilating apparatuses on at least one of its axial ends for increasing the transported volume or the pressure of the cooling medium. In another embodiment, the ventilating apparatuses on the end of the rotor shaft include a ventilating fan.

[017] In another embodiment, the rotor shaft is made separately as a forged component or is made by precision molding and pressed into the hollow interposed shaft, that is the rotor laminate pack, to achieve a force fit. In any case, the rotor is preferably made of a material of low heat conductivity and this material being advantageously a highly alloyed steel or titanium.

[018] In a favorable embodiment, the rotor shaft and the hollow interposed shaft, i.e. the rotor laminate pack, touch one another only by nearly linear contact zones for the purpose of forming minimum heat transmission surfaces. For this purpose, according to one method of the construction of a rotor shaft, the cross-section of said shaft is in the shape of a star with four points or webs, between it and an encompassing interposed shaft, which permits a large volume of cooling medium to pass between said rotor shaft and the interposed shaft, i.e. the rotor laminate pack. At the same time, this construction brings about sufficient structural strength. In yet another embodiment, the rotor shaft is designed with three sickle shaped webs so the construction of the rotor shaft will allow a high volume of cooling medium to flow between itself and the interposed shaft, i.e. the rotor laminate pack, and the formation of a large heat transfer surface with a simultaneous greater endurance to stress energy.

[019] A further embodiment shows elements for the support of a turbulence-free input of the cooling medium to the rotor. In this version, the webs are interrupted along the longitudinal contact and do not lie along their entire length against the hollow interposed shaft.

[020] In a further favorable embodiment, a heat exchanger is integrated into the electrical machine. The heat exchanger can have cooling tubes, which surround the stator and said cooling tubes can communicate, in a heat transfer manner, with provided cooling ribs. Cooling tubes can be provided directly within cooling ribs, which, with the cooling tubes which surround the stator, are inter-connectable. These cooling tubes embedded in the cooling ribs can, in one version, be installed at an angle to the cooling tubes which surround the stator. One embodiment shows the cooling ribs placed in a separate construction component, which can be mounted in the form of a cooling basin to the electrical machine.

[021] A preferred version employs air as the cooling medium.

[022]

[023] The invention will be explained and described in greater detail with the help of the drawings in which:

[024] Fig. 1 is an electrical machine with a star shaped, webbed shaft,

[025] Fig. 2 is a cross-section through a webbed shaft an rotor shaft as in Fig. 1,

[026] Fig. 3 is a cross-section through the heat exchanger, as in Fig. 1,

[027] Fig. 4 is an electrical machine with a shaft having sickle shaped internal webs,

[028] Fig. 5 is a cross-section through a webbed shaft and rotor laminate pack of Fig. 4,

[029] Fig. 6 is an electrical machine with a ventilating apparatus in the rotor shaft,

[030] Fig. 7 is a cross-section through the webbed shaft and the rotor shaft of Fig. 6,

[031] Fig. 8 is an electrical machine with a webbing arranged as an internal screw coil,

[032] Fig. 9 is a cross-section through a heat exchanger which possesses a cooling basin,

[033] Fig. 10 is a further cross-section through a heat exchanger with a cooling basin,

[034] Fig. 11 is a cross-section through the cooling basin in accord with Fig. 9, and

[035] Fig. 12 is a cross-section through the cooling basin in accord with Fig. 10.

[036]

[037] Fig. 1 shows an electric machine 2 with a rotor shaft 4, which rotates on two sets of bearings, namely 6 and 8, which are enclosed in a housing 10. The rotor shaft 4 possesses a toothed end 11, proximal to the bearing, by means of which the electrical machine 2 coacts with additional (not shown) elements of a line of drive mechanism. A rotor, a stator laminated pack 12, through which a stator winding 14 penetrates is placed in the housing 10. A rotor laminate pack 18, separated by a spacer opening 16, is situated radially within said stator laminate pack 12. The rotor laminate pack 18 is penetrated by metal pins 20, which preferably are made of aluminum. A cap 24 is fastened onto the rotor laminate pack 18 with screws 22. As an alternative, the metal pins 20 can be embedded in the rotor laminate pack 18 in a precision molding operation. The rotor laminate pack 18 is seated on a hollow interposed shaft 26, circular in cross section. The rotor shaft 4 is placed with said interposed shaft 26 by press a fit, so that it rotates as one with the interposed shaft 26. The rotor shaft can, however, be press fit directly into the rotor laminate pack. The rotor shaft 4 possesses four webs 28, which are arranged in the shape of a star (see Fig. 2). The webs 28, in the embodiment depicted here, provide open spaces 29, so that the webs 28 do not lie along their entire length against the inner wall of the hollow interposed shaft 26. In the empty spaces 30, a first cooling medium, preferably air, can be circulated through the interposed shaft 26 between the webs 28, that is, for cooling the connected rotor laminate pack 18 thereto. For this purpose, a ventilating fan 32, which brings about a flow of the cooling medium, is placed on an axial end of the rotor laminate pack 18. A steel ring sheet 34, which directs the cooling medium flowing through a heat exchanger 36 in the direction of the interposed shaft 26, without turbulence, is provided on the other axial end of the rotor laminate pack 18. The heat exchanger 36 possesses cooling ribs 38 (see Fig. 3) through which the

cooling medium flows and, in the embodiment illustrated here, these are constructed integrally with part 40 of the housing. The outward extension of the cooling ribs 38 are limited by a cover 42 which is screwed onto the housing part 40.

[038] Cooling tubes 44, through which a second cooling medium flows, are provided in the housing part 40. The heat from the first cooling medium in the heat exchanger 36 which has been transferred by the cooling ribs 38 to the cooling tubes 44 is removed from the electrical machine 2 by the second cooling medium. At the same time, heat from the stator laminate pack 12 can be transferred to the cooling tubes 44, whereby cooling of the stator laminate pack 12 is effected.

[039] In the arrangement shown in Fig. 4, the electrical machine 2 exhibits a rotor shaft 4, which possesses three webs 46 bent into a sickle shape. This sickle shape, curving form enables a high operational loading in regard to the tensile energy to be assumed by the press fit of the webbed shaft 4 into the rotor laminate pack 18. For this purpose, settings and manufacturing tolerances can be evened out, that is, compensated for.

[040] The cooling tubes 48, in the embodiment shown here, are provided with a right angled cross-section. The bearing 50, which is constructed here as a roller bearing, possesses a grease cup placed within a cap 52.

[041] In Fig. 6, no webs at all are found within the interposed shaft 26, but rather ventilating apparatuses 54, whereby in the arrangement shown here, a device 54 is provided on each end of the interposed shaft 26. The inner ring 56 of the ventilating apparatus 54 is made by means of a toothed section 58 to turn as one, with the rotor shaft 4 (see Fig. 7). The outer ring 60 turns as one with the interposed ring 26 by means of a toothed section 62. The vanes 64 of the ventilating apparatus 54 transport the first cooling medium, again preferable air, through the hollow interposed shaft 26 which is integral with the rotor laminate pack 18. The contact surfaces for the exchange of heat between the interposed shaft 26 and the rotor shaft 4, in this case, are very limited.

[042] The embodiment shown in Fig. 8, exhibits a rotor shaft 4 which is shaped in the manner of a screw conveyor. The web winds around a central shaft and,

in this way can forward the first cooling medium through the internal hollow space of the interposed ring 26 upon rotation.

[043] Again in this case, the contact surfaces between the interposed shaft 26 and the rotor shaft 4 are in a quasi, line-like surface contact along the web so that the heat transmission can be held to a predominately low level. At the same time, as in all of the foregoing described embodiments, the material of the rotor shaft 4 is so chosen that poor heat transmission is assured. A high alloy steel content or titanium would be among such materials.

[044] In Figs. 9 to 12, different embodiments of the heat exchanger 36 are described. In Fig. 9, the cooling tubes 44 are arranged so that they are only embedded in the housing part 40 to the extent of a portion of their circumference. The other portion of the circumference radiates the heat in the direction of the cooling ribs 38, which are placed in a cooling basin 66, which is cooled from the outside. The cooling basin 66 is connected to the housing 10. Fig. 11 shows a cross-section through the heat exchanger 36 of Fig. 9. The cooling tubes 44 extend outward to approach the cooling ribs 38 so that the heat can be easily transferred. The cooling basin 66 is screwed onto the housing 10 by screws 68.

[045] Also in Fig. 10, the cooling tubes 44 are arranged so that only a portion of their circumferences are embedded in the housing part 40. The other part of the circumferential area radiates the heat present in the direction of the cooling ribs 38, which are placed in a cooling basin 66. The cooling basin 66 is connected to the housing 10. Cooling tubes 70, depicted here as dotted lines, are connected with the cooling tubes 44, which are to be found proximal to the cooling ribs 38. The cooling tubes 70 penetrate the cooling ribs 38 and cross the cooling tubes 44 at an angle of 90°. In this way, the cooling tubes 70 advantageously run through the cooling ribs 38 in a meander fashion and are connected with the cooling tubes 44 at the beginning and end. The cooling tubes 70 can also be carriers of a through low temperature cooling medium which is fed from a source outside of the motor.

[046] Fig. 12 shows a section through the heat exchanger 36 in accord with Fig. 10. The cooling tubes 44 extend so far as to approach closely the cooling ribs

38, so the heat can be easily extracted therefrom. The cooling ribs here form a separate cooler 72 which is placed in the cooling basin 66.

[047] The cooling tubes 70 penetratively run through the cooling ribs 38 whereby the flow of the second cooling medium, in every two adjacent cooling tubes 70, is in a counterflow state. The cooling basin 66 is screwed onto the housing 10 by fastening screw 68.

[048] The rotor and the stator can be constructed in a compact mode of construction and thereby a high utilization of the advantages of the machine can be attained. The electrical load data of the rotor in the invented machine are not affected. An advantageous aspect is the air intake proximal to the shaft center which provides generation of pressure for ventilation.

Reference numbers and items

2 electrical machine
4 rotor shaft
6 bearing (rotor shaft)
8 bearing (rotor shaft)
10 housing
11 toothed section of rotor shaft
12 stator laminate pack
14 stator winding
16 an air gap between 12 and 18
18 rotor laminate pack
20 metal bar or pin
22 screwed connection
24 cap for 18
26 interposed shaft
28 web
29 opening to minimize heat flow
30 open space for cooling Fig. 2
32 ventilating fan (wheel)
34 a ring of sheet steel
36 heat exchanger
38 cooling rib
40 housing part
42 cover
44 cooling tube
46 web
48 cooling tube
50 bearing (Fig. 4)
52 cap for bearing grease pot
54 ventilating (cooling_ apparatus
56 inner ring
58 Toothed zone, Fig. 6
60 outer ring
62 toothed zone, Fig. 6
64 diffusor blades, Fig. 7
66 cooling basin
68 screw connection
70 cooling tube
72 cooler (Fig. 12)

Claims

Claimed is:

1. An electrical machine (2) with an external stator and an inward disposed rotor which is rotatably supported on bearings, and which machine possesses also a rotor laminate pack (18) and a rotor shaft (4) affixed rotationally with said rotor laminate pack (18), therein characterized, in that the rotor is constructed to be hollow and a cooling medium can be transported through a space between the rotor laminate pack (18) and the rotor shaft (4).

2. An electrical machine (2), in accord with Claim 1 therein characterized, in that between the rotor laminate pack (18) and the rotor shaft (4), a hollow interposed shaft (26) is inserted, upon which the rotor laminate pack (18) is placed.

3. An electrical machine (2), in accord with Claim 1 or 2, therein characterized, in that the rotor shaft (4) is constructed as a webbed shaft, which exhibits on its circumference a plurality of webs (28, 46).

4. An electrical machine (2), in accord with one of the Claims 1 to 3, therein characterized, in that the rotor shaft (4) possesses a ventilating device (32) on at least one of its axial ends for increasing the transported volume or the transport pressure of the cooling medium.

5. An electrical machine (2), in accord with Claim therein characterized, in that the ventilating device (32) at the ends of the rotor shaft (4) is constructed as a ventilating fan.

6. An electrical machine (2), in accord with one of the Claims 1 to 5, therein characterized, in that between the rotor shaft (4) and the interposed shaft (26) i.e. the rotor laminate pack (18), (18) at least one ventilating device (54) is provided for the transport of the cooling medium.

7. An electrical machine (2), in accord with one of the Claims 1 to 6 therein characterized, in that the rotor shaft (4) possesses webs (28, 46) which are in the shape of diffuser blades.

8. An electrical machine (2), in accord with one of the Claims 1 to 6 therein characterized, in that the rotor shaft (4) is constructed in the shape of a screw conveyor.

9. An electrical machine (2), in accord with one of the Claims 1 to 8 therein characterized, in that the rotor shaft (4) and the hollow interposed shaft (26), i.e. the rotor laminate pack (18), contact one another only along touching zones which are nearly linelike for the formation of smaller heat transfer surfaces.

10. An electrical machine (2), in accord with one of the Claims 1 to 9 therein characterized, in that for the construction of a rotor shaft (4), which can allow a large quantity of cooling medium to flow between it and the interposed shaft (26), i.e. the rotor laminate pack (18), and yet be constructed at the same time with sufficient structural strength, the cross-section of said rotor shaft (4) is designed in the shape of a star with four webs (28).

11. An electrical machine (2), in accord with one of the Claims 1 to 9, therein characterized, in that for the construction of a rotor shaft (4), which allows a large quantity of cooling medium to pass between itself and the interposed shaft (26), i.e. the rotor laminate pack (18), and for the provision of a large heat transfer surface at the same acceptance of stress energy, the rotor shaft (4) is designed in the shape of three sickle shaped webs (46).

12. An electrical machine (2), in accord with one of the Claims 1 to 11, therein characterized, in that the webs (28, 46) are interrupted and do not lie with their entire length against the interposed shaft (26), i.e. the rotor laminate pack (18).

13. An electrical machine (2), in accord with one of the Claims 1 to 12 therein characterized, in that the rotor shaft (4) is manufactured as a separate forged part or a precision cast part and is pressed into the hollow interposed shaft (26), i.e. the rotor laminate pack (18), to achieve a press fit.

14. An electrical machine (2), in accord with one of the Claims 1 to 13 therein characterized, in that the rotor shaft (4) is made from a material of low heat conductivity.

15. An electrical machine (2), in accord with Claim 14, therein characterized, in that the material of low heat conductivity is a high alloy steel.

16. An electrical machine (2), in accord with Claim 14, therein characterized, in that the material of low heat conductivity is titanium.

17. An electrical machine (2), in accord with one of the Claims 1 to 16, therein characterized, in that elements (34) for the support of a non-turbulent conductance of the cooling medium are provided.

18. An electrical machine (2), in accord with one of the Claims 1 to 17, therein characterized, in that a heat exchanger (36) is integrated into the electrical machine (2).

19. An electrical machine (2), in accord with Claim 18, therein characterized, in that the heat exchanger (36) possesses cooling tubes (44, 48) which encompass the stator.

20. An electrical machine (2), in accord with Claim 19, therein characterized, in that the cooling tubes (44, 48) stand in heat transferring connection with the cooling ribs (38).

21. An electrical machine (2), in accord with Claim 20, therein characterized, in that the cooling ribs (38) are placed in a separate construction component, which is in the form of a cooling basin (66) and can be installed on the electrical machine (2).

22. An electrical machine (2), in accord with Claim 20 or 21, therein characterized, in that cooling tubes (70) are provided in the cooling ribs (38).

23. An electrical machine (2), in accord with Claim 22, therein characterized, in that the cooling tubes 70 in the cooling ribs (38) are mounted at an angle to the cooling tubes (44, 48) which encompass the stator.

24. An electrical machine (2), in accord with one of the Claims 1 to 23, therein characterized, in that the cooling medium is air.

ABSTRACT OF THE DISCLOSURE

Proposed is an electrical machine (2) with an external stator and an inward located rotor, rotatably borne on bearings, and which electric machine possesses a rotor laminate pack (18) and a rotor shaft (4) connected thereto in a rotationally fixed manner, the rotor is hollow and in the space between the rotor laminate pack (18) and the rotor shaft (4) a cooling medium can be conducted therethrough.

09/890986

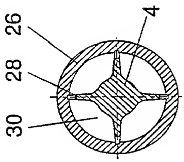

Fig. 2

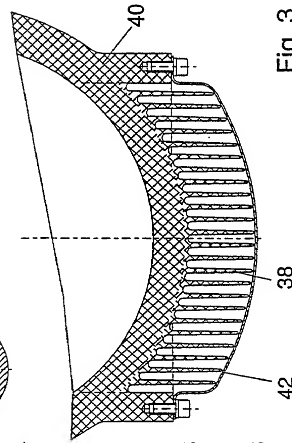

Fig. 3

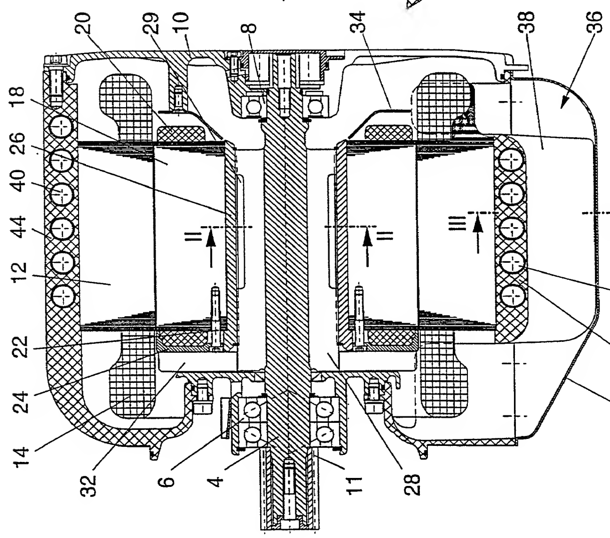

Fig. 1

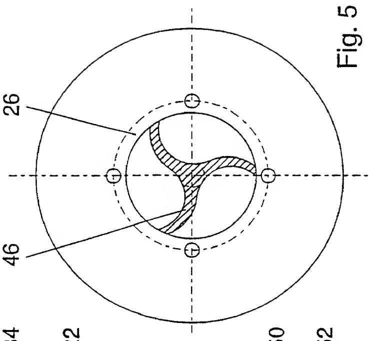

Fig. 5

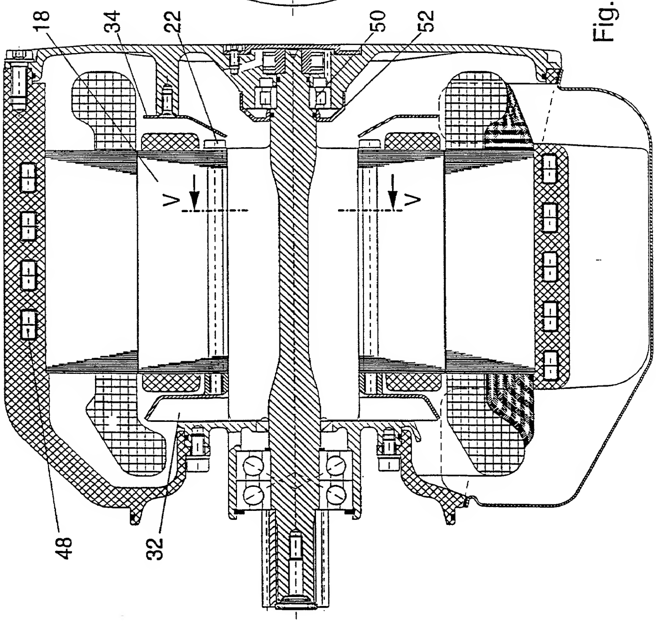

Fig. 4

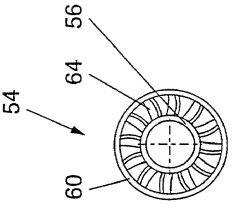

Fig. 7

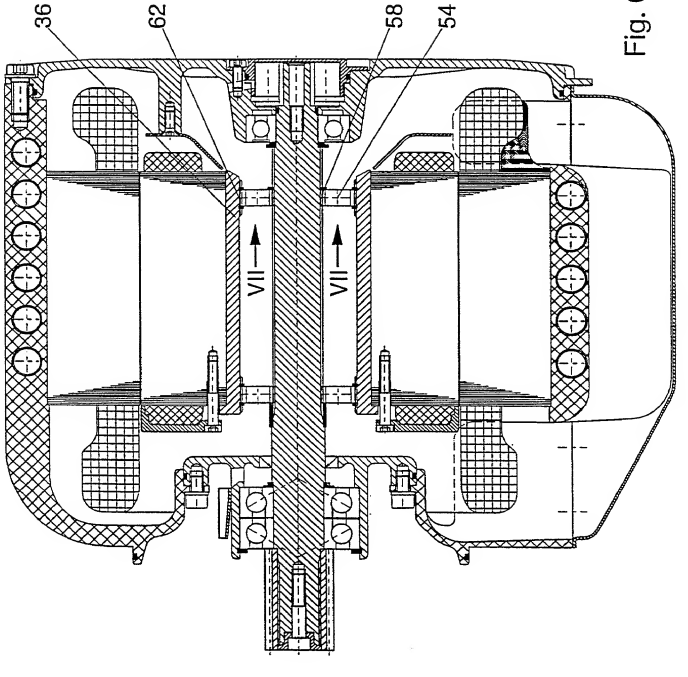

Fig. 6

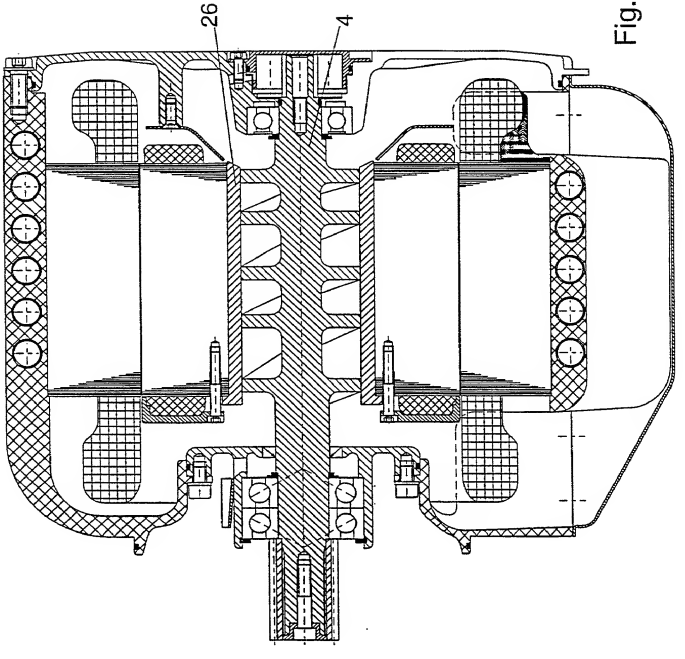

Fig. 8

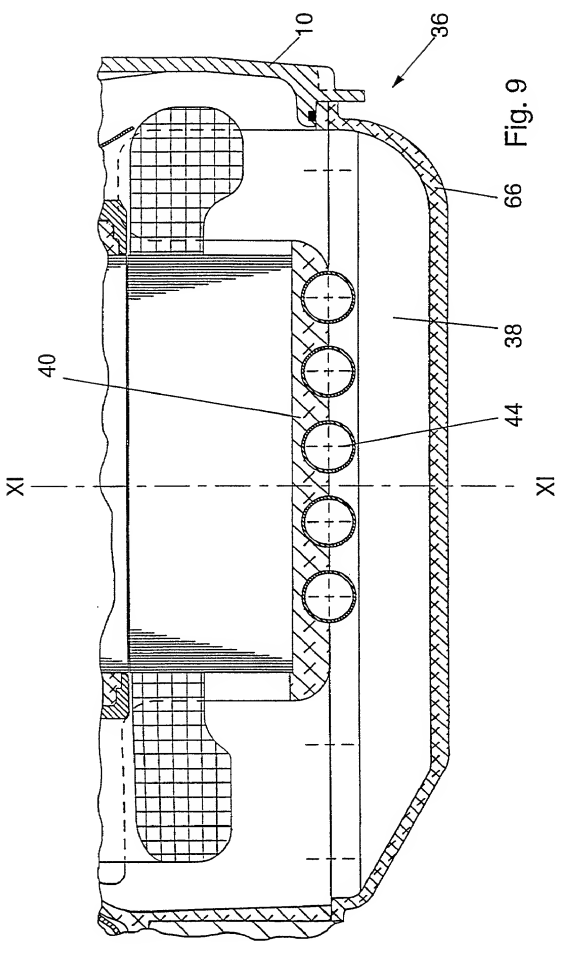

Fig. 9

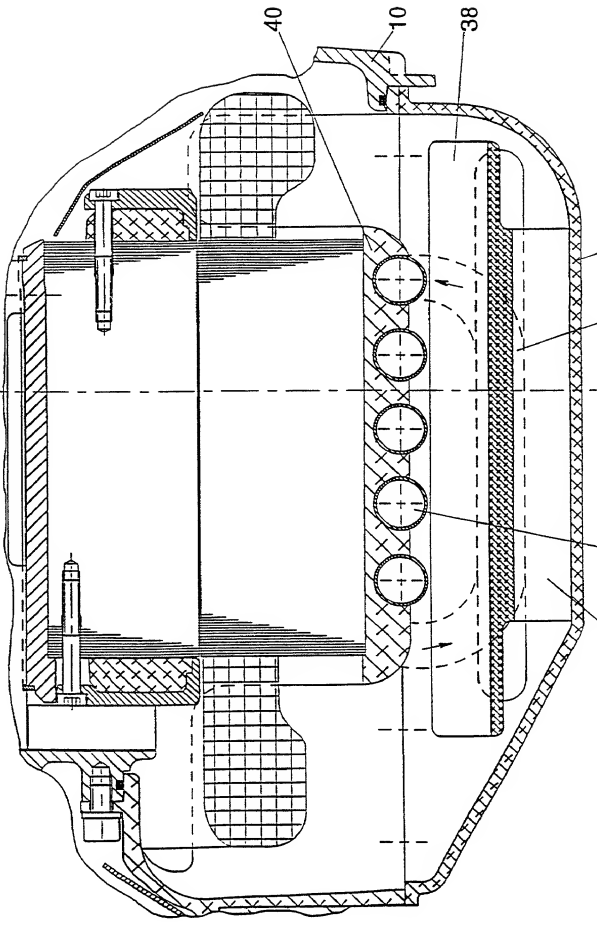

Fig. 10

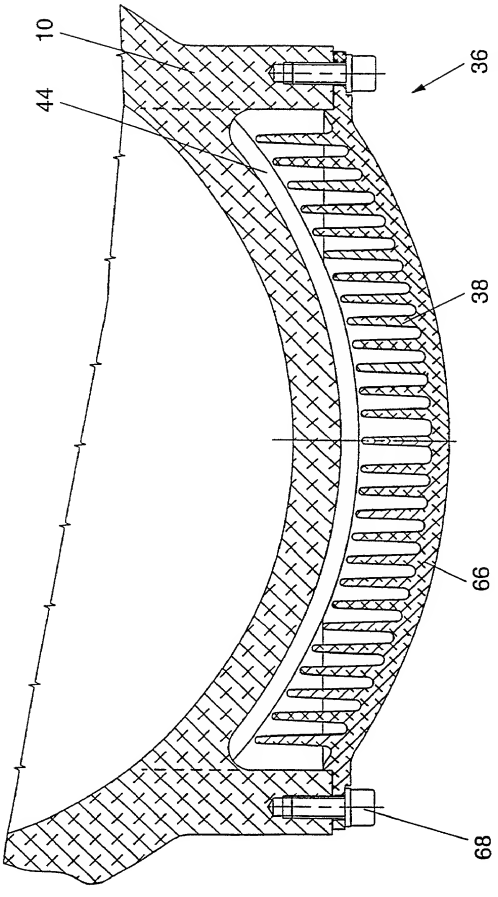

Fig. 11

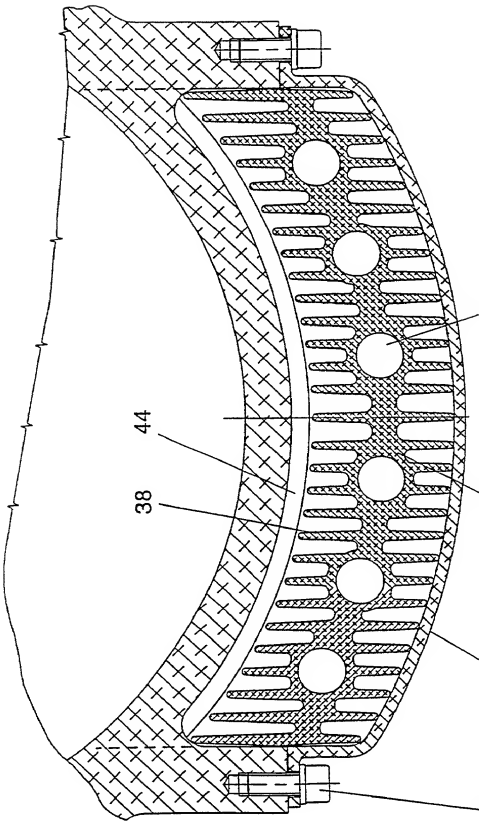

Fig. 12

ACKNOWLEDGEMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent Office all information which is known to be material to patentability of this application as defined in § 1.56 of Title 37 of the Code of Federal Regulations.

PRIORITY CLAIM

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

EARLIEST FOREIGN APPLICATION(S), IF ANY FILED WITHIN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION

COUNTRY	APPLICATION NO.	DATE OF FILING (day,month,year)	PRIORITY CLAIMED UNDER 37 USC 119
Fed. Rep. of Germany	**199 05 540.8**	**(10.02.99) 10 February 1999**	☒ YES NO
			YES NO
			YES NO
			YES NO
			YES NO

ALL FOREIGN APPLICATION(S), IF ANY FILED MORE THAN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION

DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Signature(s)

Full name of sole~~xxxxx~~st inventor **Max BACHMANN**

Inventor's signature _____ Date 18.05.01

Country of Citizenship **Fed. Rep. of Germany**

Residence **St. Leonhardstr. 36 , D-88339 Bad Waldsee , Germany** DEX

Post Office Address **c/o ZF Friedrichshafen AG, D-88038 Friedrichshafen, Germany**

COMBINED DECLARATION AND POWER OF ATTORNEY

(Original, Design, National Stage of PCT, Supplemental)

As a below named inventor, I hereby declare that:

TYPE OF DECLARATION

This declaration is of the following type: (check one applicable item below)

- ☐ original
- ☐ design
- ☐ supplemental
- ■ National Stage of PCT
- ☐ divisional (see added page)
- ☐ continuation (see added page)
- ☐ continuation-in-part (see added page)

INVENTORSHIP IDENTIFICATION

My/our residence, post office address and citizenship is/are as stated below next to my/our name. I/We believe that the named inventor or inventors listed below is/are the original and first inventor or inventors of the subject matter which is claimed and for which a patent is sought on the invention entitled:

TITLE OF INVENTION

ELECTRIC MACHINE

SPECIFICATION IDENTIFICATION

The specification of which: (complete (a), (b) or (c))

(a) ☐ is attached hereto.

(b) ☐ was filed on _____ as
☐ Serial No. _____ or
☐ Express Mail No. _____ as Serial No. (not yet known) and was amended on _____(if applicable).

(c) ■ was described and claimed in PCT International Application No. PCT/EP00/00894 filed on February 4, 2000 and as amended under PCT Article 19 on _____ (if any).

(d) ☐ amended on _____

POWER OF ATTORNEY

As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (list name(s) and registration number(s))

Anthony G. M. Davis	Registration No. 27,868
Michael J. Bujold	Registration No. 32,018
Scott A. Daniels	Registration No. 42,462

☐ Attached as part of this Declaration and Power of Attorney is the authorization of the above-named attorney(s) to accept and follow instructions from my representative(s).

Send Correspondence to:

Davis & Bujold, P. L. L. C.
Fourth Floor
500 N. Commercial Street
Manchester, NH 03101-1151

Direct Telephone Calls to:
(603) 624-9220

Direct Telefaxes to:
(603) 624-9229